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APPLICATION NUMBER: ***60/418,288***
FILING DATE: ***October 15, 2002***
RELATED PCT APPLICATION NUMBER: ***PCT/US03/29130***

By Authority of the
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10-15-02 60418288 . 101402

PTO/SB/16 (10-01)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.

jc914 U.S. PTO 10/15/02

60/418288 U.S. PTO

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☐ *Additional inventors are being named on the ______ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

AGC TECHNIQUES FOR WLCAN REPEATER

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☐ Specification *Number of Pages* 7

☒ Drawing(s) *Number of Sheets* 2

☐ Application Data Sheet. See 37 CFR 1.76

☐ CD(s), Number

☐ Other (specify)

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

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Respectfully submitted,

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Date 10/08/02

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AGC Techniques for WLAN RF Repeater

Background and Problem Statement

Currently there is a great need to extend the range of wireless local area networks. There are several standard protocols that are becoming popular. These include 802.11, home RF, and Bluetooth. The standard with the most commercial success to date is 802.11b. While the product specifications utilizing this standard commonly discuss data rates of 11 MBPS and ranges of 100 meters, these performance levels are rarely, if ever experienced. This due to attenuation of the radiation path of RF signal, typically 2.4 GHz, in an indoor environment. Ranges experienced are generally less than the coverage of a typical home, and may be as little as 10 to 15 meters. Further, in homes and businesses with split floor plans or constructed of some materials, the areas that the wireless coverage is needed may be physically separated by more than the range of the 802.11 system. This is typical of ranch homes or two story homes. Finally, the data rates of these protocols are dependent on the signal strength, and therefore this need for increased range is related to the need for higher performance at an extended range.

A way of increasing the range of wireless systems is by the use of repeaters. This is a common practice in the mobile wireless industry. One significant complication is that the receivers and transmitters operate at the same frequency for WLAN (802.11). This is significantly different than for many cellular repeater systems where the receive and transmit bands are separated by a deplexing frequency offset (IS-136, IS-95, IS-2000). This make the repeater operation easier than is the case where the receiver and transmitter bands are the same.

There are, however, cellular mobile systems that separate the receive and transmit channels by time, rather than by frequency. These utilize scheduled times for specific uplink/downlink transmissions. Repeaters for these system may be built as well because the transmission and reception times are well known and can be broadcast by a base station. The receiver and transmitter for this type of a system by be isolated by any number of means including, physical separation, antenna pattern isolation, and polarization isolation.

The random packet nature of the WLAN protocols provides no defined receive and transmit periods. The packets form each node on the wireless network are generated spontaneously, and are not predictable. A protocol is used to avoid two units transmitting their packets at the same time. This is referred to as a collision avoidance and random back-off protocol. For 802.11 this is referred to as the distributed coordination function (DCF). Repeaters intended for WLAN operation have unique constraints due to the spontaneous transmission operation, and require a solution unique to this condition.

Another unique requirement is that since these systems use the same frequency for receive and transmit some form of isolation must exist between the receiver and the

transmitter of the repeater. For CDMA systems, they employ direction antennas and physical separation of the receive and transmit antennas to achieve this isolation. This is not practical for WLAN repeaters which need to be relatively small and low cost to allow for deployment in homes, offices, Wireless hotspots and another places.

Description

This invention solves the spontaneous transmission problem and the isolation of the transceivers with a unique frequency detection and translation method. The WLAN repeater will allow two WLAN units to communicate by translating the packets from a first frequency channel used by one device to a second frequency channel used by a second device. The direction of the conversion from channel 1 to channel 2 verses from channel 2 to Channel 1 is dependent upon real time configuration. The repeater monitors both channels for transmissions, then when a transmission on a channel is detected, the repeater is configured to translate the received signal to the other channel, where it is transmitted. The details of this invention are described in detail in the figure descriptions that follow.

This approach solves both the isolation issue, allowing a small inexpensive unit, and it solves the spontaneous transmission problem as it monitors and responds in reaction to the transmissions.

A key aspect of a WLAN repeater is that to be FCC compliant, it must transmit within FCC power and spectrum limitations. This can be difficult as the received signal may have a widely varying power level, therefore to get the right signal transmit power a specialized AGC circuit is required. This invention provides detail into the AGC techniques required to enable the frequency translating repeater.

In the preferred embodiment the wireless repeater shown is capable of receiving two different frequencies simultaneously, determining which one is present, translating the frequency of the one that is present to the other frequency and retransmitting a frequency translated version of the received signal. Key features of the device are its ability receive a signal and translate the frequency of the received signal with very little distortion of the signal. This is made possible by properly controlling the gain of the transceiver via a fast and accurate Automatic Gain Control (AGC) circuit.

A key enabler is the AGC technique utilizes RF delays to allow analog storage of received waveform while signal detection and transmitter configuration takes place. This signal detection is used prior to the RF delay, and therefore provides time to perform the required configuration for the system. In the preferred embodiment, the detector power level is used to set the AGC on the parallel path.

The architecture that allows this operation, performs AGC detection of power sensing on detector path, but applies the actual gain control on IF path. Referring to Figure 3 notice that the outputs from the Log Amplifiers are feed to AGC control circuits that are

adjusting either Variable Gain or Attenuation Control elements that are part of the IF path that will be used for signal retransmission.

The two separate detectors may be used for the detection of the presence of the signal and for the power level detection to set the AGC. Further, different detection and AGC filter bandwidths may be required as the detector may occur more slowly than the AGC loop. This could be necessary because it might be required to have the AGC control of the Variable control elements to have a faster or slower response than the output of the filters after the Log Amplifiers due to system requirements.

The RF delays are implemented utilizing Surface Acoustic Wave (SAW) filters to enable both analog signal storage and channel selections, jammer suppression, and a "feed-forward" variable gain control path. The AGC "Set points" may be biased under micro-processor control from a look up table depending on which channel the signal is received on and which channel is selected for signal retransmission. This is important as different bands have different transmit power limitations in different countries. The set points may be driven by several factors resulting form meeting FCC specifications for that band these may include:

- Spectral re-growth
- EIRP

Further, addition performance may be gained when the two channels are further apart, and more transmit power may be allow and continue to meet performance requirements. The technique of adjusting the Set points based upon the fact that during signal retransmission if the selected transmit frequency is father away in the frequency then more filtering may be applied to the leakage signal coming back into the receiver thereby enabling more transmit power before significant self interference occurs.

The Actual step of choosing which channels to operate on during initial repeater power up may be influenced by the choosing repeating channels based on the ability to transmit more power in different FCC bands or other regulatory bodies. As an example in the U-NII bands for the USA the maximum allow transmit power for CH36-48 is 50mW, for CH52-64 is 250mW, and for CH 149 – 161 is 1W. Therefore it is possible to receive a signal in one of the lower power bands and pick a different band that allows higher transmit power thereby allow a higher AGC set point. This would required that the set points for the F1 to F2 AGC and the F2 to F1 AGC be different.

Another important aspect of this invention is that the AGC may require AGC calibration during initial manufacturing. This may be desirable to allow the use of lower tolerance parts to reduce cost, or for accuracy required for regional or band specific power settings. The calibration may include one or more of the following; regional regulatory rules, frequency channel, received power level, transmit power level, temperature, etc.
The repeater would have a microprocessor to integrated to aid in storing calibration tables and to pass specific calibration values to the AGC control process or circuits (as a bias.

The micro-processor would utilize a digital to analog conversion process to control the set point.

As mentioned above, different detector out-puts may be used for the AGC detection and the signal detection process. The detection process may be performed in a analog only configuration using a threshold comparator. The micro-processor may play a role in the detection process as well, as it can actively control the analog voltage the comparator is using as a reference, to make the detection decision. Alternatively the detector may be directly digitized and the detection decision may be made in an all digital fashion. One problem with using the digital path and the mirco-processor is that there is significant delay associated with the digital sampling and decision making instructions in the micro. An alternative technique is to use the analog comparator with the micro-processor controlled threshold, and with a digital override to allow for a fast initial decision, but a slower more accurate and controllable final decision using the micro-processor. An example of this is when an interferer is being detected, and the microprocessor recognizes that the packet duration is longer than the wireless protocol will allow, it may force the AGC and or the detector to turn off the output signal transmission. In this case, the AGC gain setting may be directly controlled and overridden. This is useful in a number of situation including when a system feed-back oscillation is detected.

<u>Figure 1 Description:</u>
Wide area connection 101 is connected to wireless gateway (Access point) 100. 100 sends RF signals to the client devices 104 and 105. In the preferred embodiment, these RF signals are IEEE 802.11 packets. In other embodiments they could be Bluetooth, Hyperlan, or other wireless communication protocols. Two propagation paths to each of the client devices are shown as 102 and 103. Here, the signal carried over RF path 102 is sufficient to maintain high speed data packet communications. Path 103 however, attenuates the signals intended for client device 105 to a point where little or no data packets are received in either direction.

<u>Figure 2 Description:</u>
Wide area connection 101 is connected to wireless gateway (Access point) 100. 100 sends RF signals to the client devices 104 and 105. In the preferred embodiment, these RF signals are IEEE 802.11 packets. In other embodiments they could be Bluetooth, Hyperlan, or other wireless communication protocols. Two propagation paths to each of the client devices are shown as 102 and 103. Here, the signal carried over RF path 102 is sufficient to maintain high speed data packet communications. Path 103 however, attenuates the signals intended for client device 105 to a point where little or no data packets are received in either direction.

To enhance the coverage and/or communication data rate to client device 105, a wireless repeater 200 is utilized. It performs this function by receiving the packets transmitted on a first frequency channel 201 from the AP 100. It detects the presence of a packet and then it is configured to receive the packet from the first frequency channel 201 and re-

transmit it with more power on a second frequency channel 202. Next, the client device 105, will operate on the second frequency channel, as if the AP 100 were operating on it as well. This may be performed with no knowledge that the AP 100 is really operating on the first frequency channel. To perform the return packed operation, the repeater unit 200 will detect the presence of a transmitted packed on the second frequency channel 202 from the client device 105, and will be configured to receive the signals on the second frequency channel 202, and retransmit them on the first frequency channel 201. Next, they will be received on the first frequency channel 201 by the AP 100. In this way, the repeater may receive and transmit signal at the same time and extent the coverage and performance of the AP to client connection as well a during peer-to-peer networks from client device to another client device. When the are may units that are isolated form one another, this repeater unit will act as a wireless bridge allowing two different groups of units to communicate, where RF propagation and coverage does not previously allows to.

Figure 3 Description

In the preferred embodiment the wireless repeater shown in Figure 3 is capable of receiving two different frequencies simultaneously, determining which one is present, translating the frequency of the one that is present to the other frequency and retransmitting a frequency translated version of the received signal. Key features of the device are its ability receive a signal and translate the frequency of the received signal with very little distortion of the signal. This is made possible by properly controlling the gain of the transceiver via a fast and accurate Automatic Gain Control (AGC) circuit

The preferred embodiment of the repeater AGC is comprised of two Logarithmic Amplifiers 301 & 302, two AGC control circuits 303 & 304, two gain control elements (variable gain or variable attenuators) 305 & 306, and four analog storage devices (delay lines and/or band pass filters) 307 through 310 Additionally part of a possible detection circuit consist of two low pass filters 311 & 312, two Analog to Digital Converters (ADC) 313 & 314, and a microprocessor 315.

Because the repeater must be able to simultaneously detect and process two different frequency the received signals are split into two different RF paths by RF Splitter 316. Likewise, because the two different frequency paths must be delayed and control separately they are again split by two IF Splitters 317 and 318. The outputs from the IF Splitters go to the two LogAmps 301 & 302 or the gain control elements 305 & 306.

301 & 302 provide an accurate voltage at their output that is proportional to the Logarithm of the input signal. These amplifiers essentially track the envelop of the input waveform. The output of the LogAmps is feed to AGC control circuits 303 & 304. These control circuits provide filtering of the analog voltage at the output of the LogAmps as well as any necessary DC offset adjustment, AGC set point reference and control, level shifting/scaling, and any required polarity reversal. The output of the AGC control circuits are feed to the gain control elements 305 & 306. These elements provide either adjustable gain or adjustable attenuation of the signal based on the desired transmitter output power.

As a example, if a variable attenuator is being used for the gain control element and the following conditions exist:

- Desired Output Power 15dBm
- Received Signal Power -80dBm
- Total Transceiver Losses 65dB
- Total Transceiver Gains 165dB

Then the Variable Attenuator should be set to:

Attenuations = Rx Signal Power - Desired Output Power + Total Gains - Total Losses
Attenuations = -80dBm – 15dBm +165dB – 65dB
Attenuations = 5dB

There is an associated voltage that may be applied to the attenuator that will result in a 5dB attenuation setting. The AGC control circuit is capable of performing the required calculation previously show to derive the proper voltage.

A key element in the sequencing of the gain control is that the output voltage from the LogAmp is split to two different circuits, with potentially two different filter bandwidths. One path goes to the AGC control circuit as previously described while the other path goes to two low pass filters 311 & 312. This means that, if desired, the AGC control and the signal detection filter bandwidth could be set different. As an example, if it were desired the AGC control loop could be set to react very quickly to the incoming power envelop while the signal going into the detections circuit, in this case shown as ADC 313 & 314 and a processor 315, to be made to react slower. This would mean that the signal going through the gain control elements 305 & 306 can be tracked very accurately while the signal going into the detection circuit 313, 314, & 315 may be set to respond slower but with more detection process gain.

Another key element is the fact that the signal to be retransmitted is delayed via four SAW filters 307 through 310. This delay essentially stores the analog waveform while the AGC and signal detection processes are occurring. This means that by the time the signal has propagated through the filters, detection of the signal on either channel has occurred as well as the setting of the gain control.

After detection and setting of the gain control has occurred the IF Switch 319 and the LO Switch 320 will be set to retransmit the received signal at a different frequency without having cutoff much, if any, of the waveform preamble.

Various techniques can be utilized to determine AGC set points as well as different signal detector configurations. These are outline in the Key Analog Gain Control Concepts to Protect section that follows this section.

Key Analog Gain Control (AGC) Concepts to Protect

- AGC techniques utilizing delays to allow analog storage of received waveform while signal detection and transmitter configuration takes place
    - Utilizing Surface Acoustic Wave (SAW) filters as delays to enable both analog signal storage and channel selections and jammer suppression
- AGC Set points based on which channel the signal is received on and which channel is selected for signal retransmission
    - Where the set points are based on meeting FCC specification for that band
        - Spectral re-growth
        - EIRP
    - Set points are based upon the fact that during signal retransmission if the selected transmit frequency is father away in the frequency then more filtering may be applied to the leakage signal coming back into the receiver thereby enabling more transmit power before significant self interference occurs
    - Pick repeating channel based on the ability to transmit more power in different FCC bands or other regulatory bodies. As an example in the U-NII bands for the USA the maximum allow transmit power for CH36-48 is 50mW, for CH52-64 is 250mW, and for CH 149 – 161 is 1W. Therefore it is possible to receive a signal in one of the lower power bands and pick a different band that allows higher transmit power thereby allow a higher AGC set point.
- AGC on detector path, but apply the actual gain control on IF path. Referring to Figure 3 notice that the outputs from the Log Amplifiers are feed to AGC control circuits that are adjusting either Variable Gain or Attenuation Control elements that are part of the IF path that will be used for signal retransmission.
    - Different detection and AGC filter bandwidths. This could be necessary because it might be required to have the AGC control of the Variable control elements to have a faster or slower response than the output of the filters after the Log Amplifiers.
- AGC calibration which may include one or more of the following; regional regulatory rules, frequency channel, received power level, transmit power level, temperature, etc. Having a microprocessor to:
    - Store calibration tables
    - Pass specific calibration values to the AGC control process or circuits
    - Utilize a digital to analog conversion process to control the set point
- Threshold comparator techniques
    - Analog only
    - Digital and analog
        - Analog AGC control w/digital override
            - Analog Loop with Digital Turn off control
            - Direct Digital gain settings
        - Digital Set point with analog control

Figure 1 Current Situation

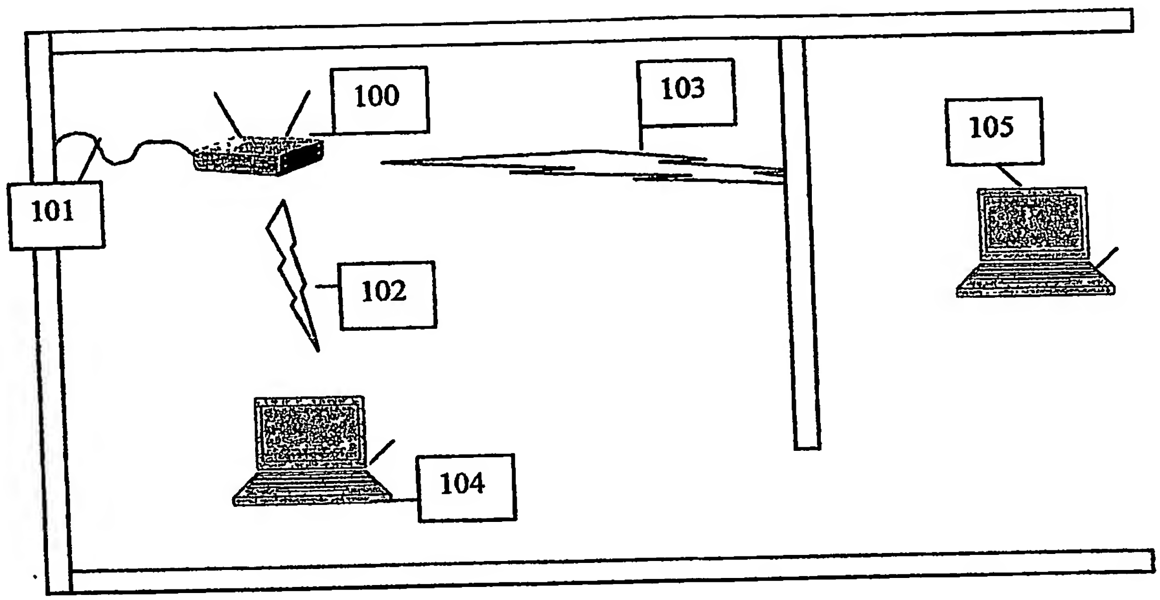

Figure 2 Wireless Repeater Solution

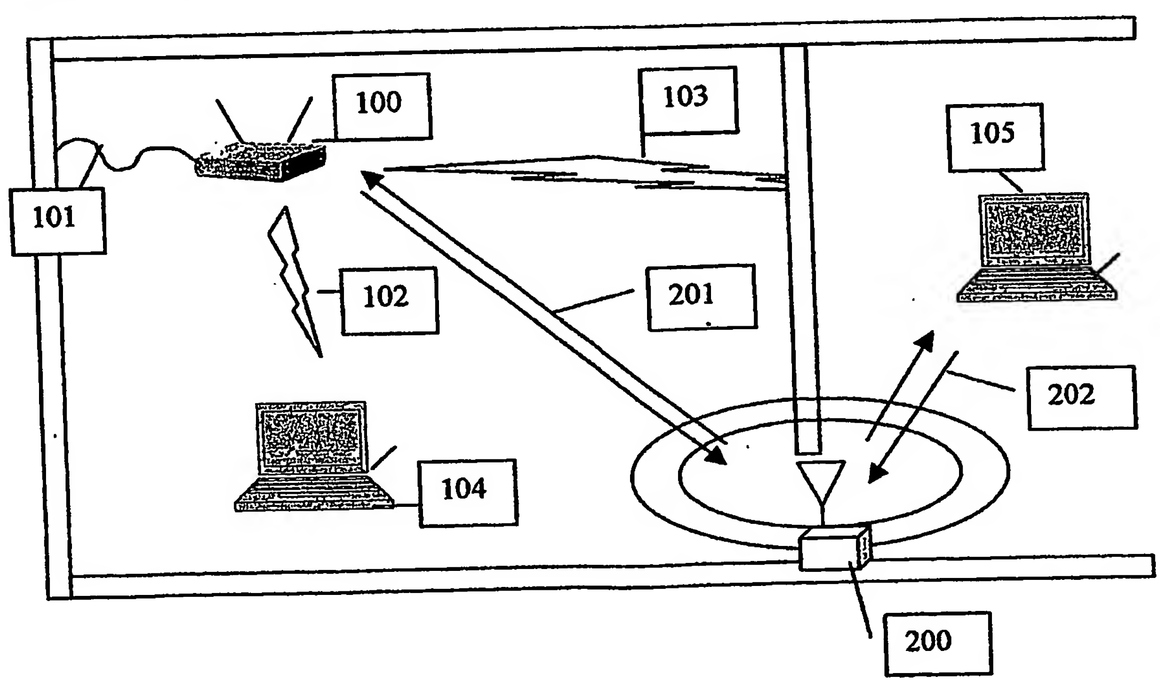

Figure 3 Detailed Block Diagram of WLAN Repeater